

CMOSIC for Current-Mode PWM Power Supply

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1. Introduction

In recent years, as energy conservation has become an important environmental protection measure, considerable attention has been given to increasing the efficiency and lowering the power consumption of switching power supplies widely used in electrical and electronic equipment. As a result, the use of products with a remote controller or a timer is increasing, and the use of power supply circuits with standby mode (low power consumption) is increasingly in products normally connected to power supplies in order to reduce the power consumption during standby.

Control ICs manufactured with a bipolar process have been developed for AC-DC converters that transform a commercial AC supply into a DC supply. The power consumption of the control ICs themselves under minimum load conditions in the standby mode has been reduced to targeted levels.

Utilizing high-voltage CMOS process technology accumulated during the development of technologies such as high-voltage driver ICs used in liquid crystal panels and thermal heads for printers, Fuji Electric has developed the FA1384X series of 8-pin CMOS (complementary MOS) ICs for current-mode power supply control. This paper presents an overview of the FA1384X series.

2. Product Outline

Using a bipolar process, Fuji Electric has already developed the series of ICs listed in Table 1 for AC-DC converter control. Recently, Fuji Electric has used a CMOS process to develop 8-pin current-mode power supply control ICs and bring them to market.

This control system maintains a constant peak current for power MOSFETs (metal-oxide-semiconductor field-effect transistors) and is widely used for designing power supplies because it is rarely affected by voltage regulation loop delays, making it easy to design stable power supplies.

Table 2 shows main features of the FA1384X series. Figure 1 shows a diagram of the IC chip.

2.1 Features

The newly developed FA1384X series of 8-pin CMOS ICs for current-mode power supply control have the same pin arrangement and function as the 384X series of other companies, the so-called industrial standard, and is provided with two types of packages, DIP (dual inline package) and SOP (small outline package).

Features of the ICs are listed below.

- (1) Reduced electric current due to utilization of a CMOS process
- (2) Latching PWM (pulse width modulation) control performs pulse-by-pulse current limiting
- (3) UVLO (undervoltage lock out) circuit with hysteresis characteristics
- (4) Different product models with different maximum duties are provided for flyback and forward circuits

FA13842/44: 16.5V on/9V off

FA13843/45: 9.6V on/9V off

Where $R_T = 10k\Omega$, $C_T = 3.3nF$

2.2 Circuit configuration and devices

Figure 2 shows a block diagram of the FA1384X series.

The block diagram consists of high and low voltage sections. The high voltage section is comprised of a reference voltage generator, a UVLO circuit for undervoltage protection and an output driver circuit connected to a VCC pin. The low voltage section is comprised of an oscillator, an error amplifier and a current sense comparator connected to the reference voltage generator.

2.2.1 Devices

In the manufacturing process, two gate oxide film thicknesses are used for 30V high-voltage MOS devices and 5V low-voltage MOS devices, respectively. CMOS circuits can be configured for both high and low voltages.

Combining a heavily doped region used to create the source and drain in ordinary CMOS processes with a lightly doped region for high voltage use enables

Table 1 IC product series for AC-DC converters

Type (number of pins)	Operating voltage	Maximum opera- ting frequency Maximum duty cycle	Output current	Error amplifier	Reference voltage	Function	Application
FA5301BP/BN (16 pins)	7 to 22V	200kHz Arbitrary	20mA (DC)	Built-in	5V ±5%	External synchronization Overload / overcurrent	CRT monitor display
FA5304AP/AS (8 pins)	10 to 30V	600kHz 46%	±1.5A (peak value)	2.0V ±5%	—	Overload / overvoltage Overcurrent (positive voltage sensing)	General-purpose power supply
FA5305AP/AS (8 pins)	10 to 30V	600kHz 46%	±1.5A (peak value)	2.0V ±5%	—	Overload / overvoltage Overcurrent (negative voltage sensing)	General-purpose power supply
FA5310BP/BS (8 pins)	10 to 30V	600kHz 46%	±1.5A (peak value)	—	—	Overload / overvoltage Overcurrent (positive voltage sensing)	General-purpose power supply Forward converter
FA5311BP/BS (8 pins)	10 to 30V	600kHz 70%	±1.5A (peak value)	—	—	Overload / overvoltage Overcurrent (positive voltage sensing)	General-purpose power supply Flyback converter
FA5314P/S (8 pins)	10 to 30V	600kHz 46%	±1.5A (peak value)	—	—	Overload / overvoltage Overcurrent (negative voltage sensing)	General-purpose power supply Forward converter
FA5315P/S (8 pins)	10 to 30V	600kHz 70%	±1.5A (peak value)	—	—	Overload / overvoltage Overcurrent (negative voltage sensing)	General-purpose power supply Flyback converter
FA5316P/S (8 pins)	10 to 30V	600kHz 46%	±1.0A (peak value)	—	—	Overload / overvoltage Overcurrent (positive voltage sensing)	General-purpose power supply Forward converter
FA5317P/S (8 pins)	10 to 30V	600kHz 70%	±1.0A (peak value)	—	—	Overload / overvoltage Overcurrent (positive voltage sensing)	General-purpose power supply Flyback converter
FA5321P/M (16 pins)	12 to 27V	500kHz 50%	±1.5A (peak value)	2.4V ±8%	—	Current mode External synchronization Overload / overvoltage Overcurrent (positive voltage sensing)	General-purpose power supply
FA5331P/M (16 pins)	10 to 28V	220kHz 92%	±1.5A (peak value)	1.54V ±4%	5V ±4%	External synchronization Overvoltage / overcurrent	Power factor controller

Table 2 Main features of FA 1384X series

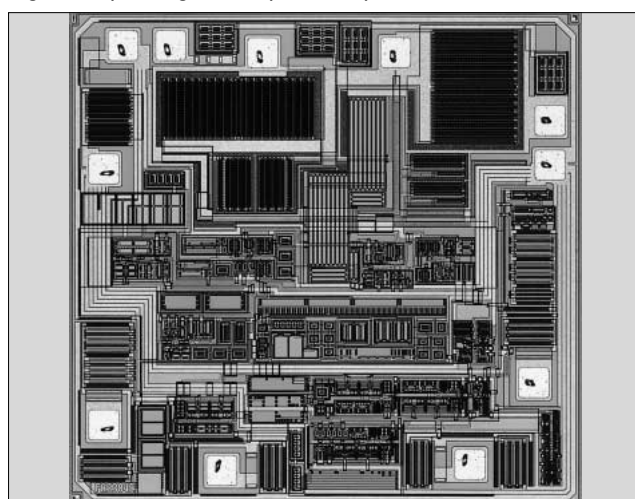
(a) Absolute maximum ratings

Item		Property
Supply voltage		10 to 28V
Output peak current	Source current	400mA
	Sink current	1.0A
Operating frequency		10 to 500kHz
Ambient temperature		- 25 to +85°C
Junction temperature		150°C

(b) Electric characteristics

Item		Property
Start-up current		12μA (standard)
Standby current ($V_{CC} = 14V$)		2μA (maximum)
Current consumption during operation ($C_L = 1,000pF$)		3mA (standard)
Reference voltage		5V±5%
Error amp. feedback input voltage		2.5V±4%
Current sense maximum input signal		1V±0.1V
Output rise time ($C_L = 1,000pF$)		40ns (standard)
Output fall time ($C_L = 1,000pF$)		20ns (standard)

Fig.1 Chip configuration (FA13842)



bipolar devices such as npn transistors, pnp transistors and Zener diodes to be configured. A band gap reference voltage circuit with these npn transistors is utilized in the reference voltage generator.

2.2.2 UVLO circuit

The circuit configuration shown in Fig.3 was

Fig.2 Block diagram

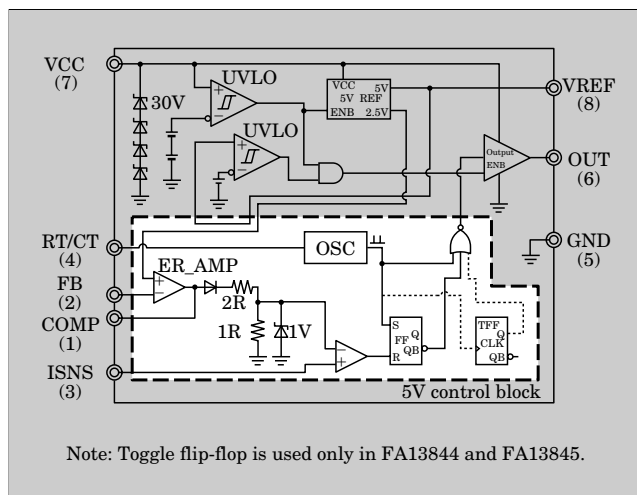


Fig.3 Undervoltage lockout circuit (UVLO)

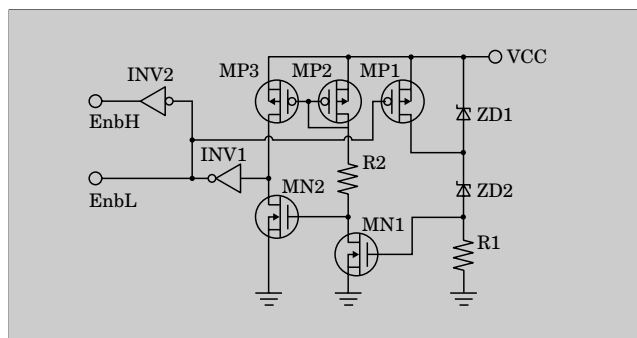
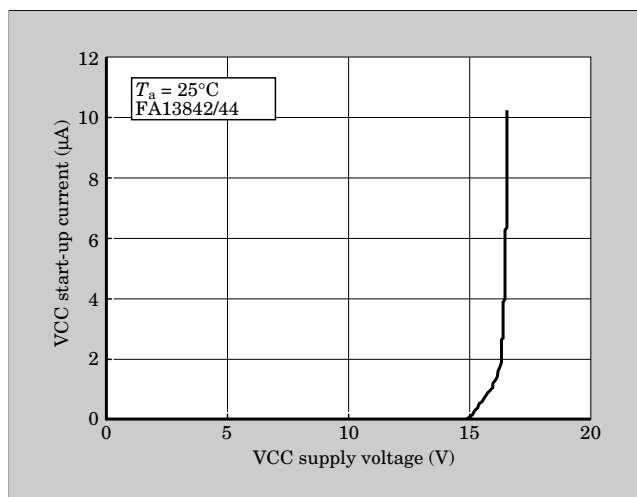


Fig.4 Start-up current



adopted in order to utilize the advantages of the CMOS process and to reduce current consumption before start-up.

Current consumption is almost zero because MN1 is off until VCC voltage exceeds the Zener voltage. Standby current for the entire IC is also almost zero because the bias current of other circuit blocks can be

Fig.5 Output driver circuit

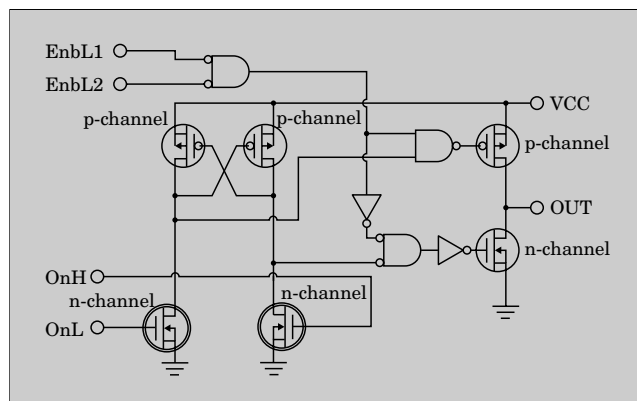
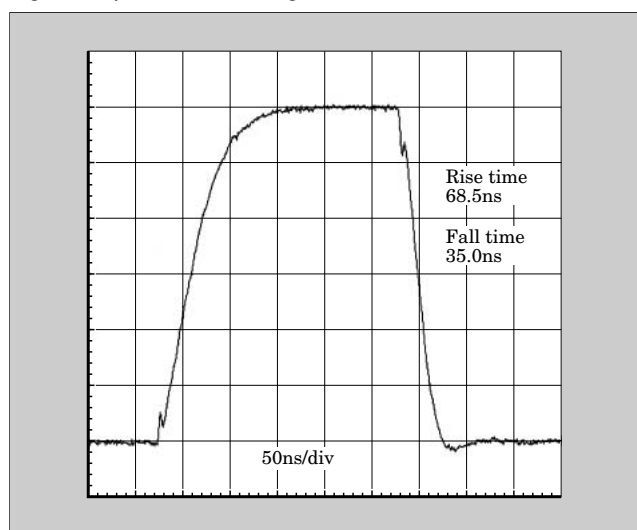


Fig.6 Output terminal voltage waveform



fixed to zero by an output H/L logic signal. Figure 4 shows current consumption characteristics until immediately before start-up. Standby current is almost zero when the VCC supply voltage is less than 14V, and a little over 10μA just before start-up.

As the VCC voltage is raised further, MN1 turns on, reversing the output logic. A bias current begins to flow in each transistor, initiating operation. When MP1 turns on, the voltage hysteresis of the UVLO circuit is determined.

2.2.3 Output driver circuit

The FA1384X series has a built-in output driver circuit with a CMOS inverter configuration. This allows the MOSFET gate voltage for switching to fully swing up to the VCC voltage using a level shifter. When switching between high- and low-levels, the current flowing to GND can be reduced by setting a period of several tens of nanoseconds as the interval when both the p-channel at the VCC side and the n-channel at the GND side are turned off at the same time.

Figure 5 shows a block diagram of the driver circuit. After a 5V-amplitude logic signal (OnH/OnL)

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The graph shows the start-up time in seconds as a function of the start-up resistance R_1 in $k\Omega$ for an AC100V input. Three curves are plotted for different values of the capacitor C_2 :

- $C_2 = 47\mu F$: This curve shows the highest start-up time, reaching 4 seconds at $R_1 = 500 k\Omega$.
- $C_2 = 22\mu F$: This curve shows a moderate start-up time, reaching 4 seconds at $R_1 = 1000 k\Omega$.
- $C_2 = 10\mu F$: This curve shows the lowest start-up time, reaching approximately 1.8 seconds at $R_1 = 1000 k\Omega$.

In all cases, the start-up time increases linearly with the start-up resistance R_1 .

Figure 6 shows the waveform of the output terminal voltage with a 2,200pF capacitor connected to the output terminal as a load. The rise time is 68.5ns and the fall time is 35ns. The fall time was designed to be shorter than the rise time because in driving the n-channel power MOSFET, faster speed is required for the fall state when the gate turns off than for the rise state when the gate turns on. When VCC voltage is

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because more time is required to charge the capacitor C2. Consequently, the values of the resistance and capacitance should be selected in consideration of actual operating conditions.

Figure 8 shows the relationship between start-up time and start-up resistance R1 with capacitance C2 as a parameter.

Figure 9 shows a method to reduce the start-up time even with a high start-up resistance. Decreasing the capacitance of C3 reduces start-up time, and after start-up, current is supplied from C2.

4. Conclusion

This paper presented an overview of the newly developed CMOSICs for current-mode AC-DC converters. CMOS-type ICs have the advantages of being suitable for lower power consumption and are easy to incorporate in logic circuits. In addition to the ICs discussed in this paper, Fuji Electric plans to develop other CMOS-type ICs for switching power supply control.





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